BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: Review of Role of MSFN Station at Grand Canary Island in Apollo and AAP - Case 900

DATE: March 8, 1968

FROM: J. P. Maloy

ABSTRACT

The functions performed by the MSFN station at Canary Islands (CYI) for Apollo and AAP missions are reexamined. It is concluded that the need for CYI is marginal for Apollo lunar landing missions with the removal of the requirements for injection on the second half of the first orbit. However, it is apparent that CYI contributes significantly to the coverage of long duration Apollo test and AAP missions.

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MEMORANDUM FOR FILE

In view of changed requirements, primarily that there is no requirement for injection on the first revolution for lunar missions, the need for a station at Grand Canary Island has been reviewed.

The "Support Requirements Reference Handbook for the Apollo Saturn IB/Saturn V Programs," published by NASA Headquarters (MAO) (revised July 1966) lists the support capabilities and functions for a station at Grand Canary Island as:

> "Grand Canary Island will be the first station to provide validation of Cape Kennedy - Bermuda orbital track data at launch azimuths less than 85 degrees. This will be a primary station for supporting the near-space phases of the Apollo missions and will provide:
>
> (1) C-Band radar tracking.
>
> (2) VHF telemetry reception of space vehicle engineering and/or operational links.
>
> (3) PCM data separation.
>
> (4) Digital Command System.
>
> (5) UHF up-data transmission.
>
> (6) VHF air-to-ground (A/G) voice communication.
>
> (7) Unified S-Band system, with 30-foot dish and telemetry, voice, ranging, and up-data capability."

A memorandum entitled "Instrumentation for Apollo at the MSFN Site at Canary Islands," by Messrs. J. J. Hibbert and J. P. Maloy, dated October 20, 1964 (see Appendix A),

supported an MSFN station at Grand Canary Islands (CYI) for the following major reasons:

1) CYI provides unique coverage on the first orbit for launch azimuths (72°-82°) that will frequently be used for test and lunar missions.

2) CYI would be needed to send up-data to the SIVB/IU to check it out prior to injection on the first revolution over the Pacific near Australia on lunar missions.

3) CYI provides up-data capability to the CSM and tracking for supporting aborts that occur near or shortly after insertion into Earth orbit.

However, some of the three major requirements listed in this memorandum are no longer mandatory. At the time it was written, injection on a lunar trajectory during the last half of the first revolution was a tentative requirement. This is no longer required so that the second reason for CYI listed above loses its significance. The unique coverage provided by CYI on the first revolution in the launch azimuth range of 72°-82° would have been very desirable for injection opportunities during the first revolution, but not for normal Earth orbital operations. Figures 2 and 3 of Appendix A would indicate that there are more than the minimum number of station contacts for Earth orbital operations during the first revolution without the CYI station.

Also it was believed that the Insertion Ship alone might not provide reliable and accurate space vehicle position and velocity data for orbital determinations and that a station such as CYI would be needed to provide corroborating data early enough to substantiate the track. The ships have subsequently demonstrated on various test missions that they are capable of performing this function with sufficient accuracy by themselves.

The Insertion Ship would provide data for a close-in abort just prior to insertion, but in the event of a near miss at insertion resulting in an abort, it would be important to have a down-range station acquire the space vehicle soon to provide telemetry and tracking data for space vehicle recovery. CYI would meet this requirement for launch azimuths between 72° and 82°. This is a unique function that can be provided by the CYI station for all Apollo and AAP missions.

In summary then, requirements have changed so that the necessity for maintaining a station at Grand Canary Island for Apollo lunar missions is marginal. The results of this review indicate that only one of the major reasons for retaining CYI is still valid; i.e. near insertion abort support capability; the other important considerations, namely confirmation of Earth orbit and SIVV/IV checkout prior to injection on the first orbit are no longer appropriate.

Use of CYI Station for Apollo Applications Program (AAP) Missions

A computer run was made for two days of coverage for thirteen MSFN stations as a comparison with previously published Bendix data.* Some variations in coverage analysis were made as follows:

(1) Bendix did not include coverage by stations for passes whose maximum elevation was less than 5° above the local horizon. No attempt was made to remove these low elevation passes from our results. It is believed such passes are relatively few in number and would have no significant impact on these results.

(2) Bendix began their revolution count at 45°W. This study followed the more usual convention of counting revolutions as the space vehicle passes over the longitude of Cape Kennedy. This difference should have no significant effect on the end results.

(3) No ships were utilized in the present study. Bendix showed results with and without ships.

No mention was made in the Bendix report of keyhole considerations, masking of ground antenna patterns due to terrain or other obstructions or a minimum coverage duration. In order to make the reports comparable, these affects were likewise omitted in the Bellcomm analysis, but will be reexamined in a later study.

Table I is a summary of the number of contacts and total number of coverage minutes that each station had for

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*ED 2002-375 "Apollo Applications Program (AAP) Payload Integration," dated 23 February 1968, presented at the AAP I&C Panel Meeting at MSFC on 27 Feburary 1968.

the two-day period. It indicates that CYI provides 12% of the number of contacts and 13% of the contact time. This compares with 13% and 11% respectively in the Bendix study, whose results are shown in Table IA. The gaps between contacts are not comparable for the two studies since the duration of the runs were so different (2 days vs. 56 days). Table II shows the number of gaps would increase if CYI were removed from the station network; the number of gaps greater than 35 minutes would increase by 5 (from 33 to 38); those greater than 75 minutes by 1 (from 5 to 6); and one gap would exceed 200 minutes.

The summary of the data just reviewed indicates a need for CYI. It provides the same number of contacts as Ascension (ACN) (11), more contact time than ACN (83 vs. 71 minutes) and slightly more than Guam (GWM) (83 vs. 82). However, the answer as to how many of these contacts and how much of the contact time is necessary is not readily apparent. This depends upon the operational plans. However, the CYI station would reduce some of the large gaps.

Coverage of the MSFN Station at Tananarive (TAN)

For 4 out of 11 contacts in the two days examined, TAN has a contact following the one at CYI. In none of these cases, would the gap from "time last seen" at CYI exceed 35 minutes if TAN were not there since Carnarvon (CRO) picks up the space vehicle within ten minutes after TAN does. However, if neither CYI nor TAN (nor an equivalent ship) were in the MSFN network (see Table II) then gaps exceeding 35 minutes would increase from 33 to 42 and gaps exceeding 70 minutes would increase from 5 to 7. It is apparent that, CYI and TAN are comparable in the coverage that they provide for a two-day AAP mission.

Conclusions

Although the usefulness of CYI for Apollo lunar missions is marginal due to changed requirements, it is apparent that CYI can provide significant coverage for long duration (Apollo and AAP) missions. If such coverage were not required, the relocation of the CYI facilities to TAN would permit the deletion of the requirement for a ship in the South African area.

J. P. Maloy

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Attachments

BELLCOMM, INC.

SUBJECT: Instrumentation for Apollo at the MSFN Site at Canary Islands. Case 215

DATE: October 20, 1964

FROM: J. J. Hibbert
J. P. Maloy

SUMMARY

The only S-band capability provided at the Canary Island (CYI) site of the MSFN for Apollo in the present implementation plan is reception of telemetry from the Apollo spacevehicle (SIVB/IU and CSM). The requirements for CYI have been re-examined and support a recommendation to equip CYI with a complete Unified S-band Station (30 ft diameter antenna) of single capability, i. e. it should be able to transmit to one spacecraft at a time while receiving data from two.

The major reasons for this recommended change in the implementation plan are:

1) CYI provides unique coverage on the first orbit for launch azimuths (72° - 82°) that will frequently be used for test and lunar missions.

2) CYI is needed to send up-data to the SIVB/IU to check it out prior to injection over the Pacific near Australia on lunar missions.

3) CYI should be provided with CSM up-data capability and redundant tracking for supporting aborts near or shortly after insertion into earth orbit.

SUBJECT: Instrumentation for Apollo at the MSFN Site at Canary Islands Case 215

DATE: October 20, 1964

FROM: J. J. Hibbert
J. P. Maloy

MEMORANDUM FOR FILE

Introduction

The general purpose of this memorandum is an examination of Apollo requirements for instrumentation for the Manned Space Flight Network (MSFN) site at Canary Islands (CYI). The specific purpose is to determine whether the current MSFN implementation plan should be modified so that the Canary Island site is equipped with a complete unified S-band installation.

Functions Performed by the Canary Island Site

The Canary Island (CYI) site is the first land-based MSFN site that can track and communicate with the Apollo space vehicle after insertion into Earth orbit on launch azimuths between 72° and 82°. The next station that would communicate with the space vehicle on these launch azimuths is Carnarvon (CRO), Australia.

Figure 1 shows the contact time for each MSFN station during which the space vehicle is above 5° elevation, for the first half of the first orbit after the space vehicle is inserted into Earth orbit on launch azimuths between 72° and 108°. For this data, the injection ship was positioned to cover injection into the lunar transfer trajectory for the lunar missions. It is apparent for launch azimuths between 72° and 80°, that CYI reduces the coverage gap between the insertion ship and CRO from 37 minutes to 30 minutes.

Tracking

Because of its location, CYI tracking data provides the first confirmation and refinement of the insertion ship's evaluation of the insertion of the space vehicle into Earth parking orbit for launch azimuths near 72°. Many of the test missions as well as the start of the launch window for lunar

missions will use these launch azimuths so this tracking function at CYI is important. Moreover, CYI will be connected by cable to the IMCC in the next year which will assure the availability of this data.

The tracking at CYI is now performed by an MPS-26 radar which operates at C-band and has tracking performance quite comparable to that expected from the unified S-band (30 ft. diameter antenna) station in angle and range tracking. The MPS-26 radar will be used for tracking the Gemini spacecraft and can be used for tracking the Apollo space vehicle since it will carry a C-band beacon either in the SIVB/IU or in the CSM or both.

For launch azimuths between 72° and about 82°, as shown on Figure 1, Australia would be the next range station to provide tracking data if the MPS-26 radar at CYI failed. Particularly in the case of an abort near insertion into Earth orbit on these launch azimuths the need for tracking data would support a requirement for redundant tracking facilities at CYI. At other launch azimuths (82° - 100°) the Injection Ship provides redundant tracking facilities since it has both a C-band radar and a USB installation. Also Ascension can provide good tracking data between about 90° and 100°.

Telemetry Reception

The telemetry receiving equipment at CYI is now in the VHF band, which will be used for telemetered engineering data from the SIVB/IU on the Saturn V lunar mission, and for operational data on many of the Saturn IB missions. When the Apollo spacecraft and the SIVB/IU are also equipped with unified S-band gear, CYI must be equipped with telemetry receiving equipment to receive the S-band telemetry.

Voice Communications

CYI is now equipped to receive and transmit voice in the VHF frequency band to the Gemini spacecraft. These facilities can also be used to provide voice communication with the Apollo spacecraft since they are to be equipped with VHF voice equipment for communication in the vicinity of the moon although the primary voice link to the Block II spacecraft will be the Unified S-band equipment.

Up-Data Transmission

For the Saturn IB missions data will be sent to the SIVB/IU and the CSM Block I over the UHF command equipment installed at CYI for the Gemini missions.

The UHF up-data receivers will be deleted from the Block II CSM and will also be removed from the SIVB/IU used with Saturn V. Therefore, it would not be possible to send data automatically to the Apollo space vehicle from CYI for Saturn V flights unless a USB station were installed there. To be sure, voice data could always be transmitted to the Apollo CSM but simulation exercises for Gemini show that the time required to do this would probably be too long to complete in a single station pass.

Up-data transmission is needed at CYI in order to, 1) check out the SIVB/IU for a lunar mission prior to injection into the lunar transfer trajectory in the Western Pacific during the first orbit. Discrete commands will be sent to the SIVB/IU for this purpose. Since the SIVB second burn sequence takes about 7 minutes, the decision to "go" must be made prior to the Australian stations (CRO). 2) Send data to the CSM in case of an abort near the insertion into Earth orbit. Although the Insertion Ship can do this in most cases, there can be aborts where abort reentry must be implemented by CYI.

If a satisfactory Earth orbit is not achieved, and for some reason the insertion ship is unable to transmit data to the Apollo vehicle for emergency reentry, CYI should be able to perform this function. Although CYI can always send some data by voice to the spacecraft, as was done in the Mercury flights and even though aborts are under control of the astronauts, such voice data for emergency abort is quite marginal for the Gemini and Apollo missions.

Injection Considerations

By seven minutes after the end of the injection burn, the coverage provided by CYI during the translunar injection phase is redundant with that provided by Madrid and Ascension Island. Also, by this time the CYI coverage of injection is redundant with that of the insertion ship. Of course, if injection occurred near CYI, it would be able to provide communication and tracking for a few minutes of the injection phase, although communication aircraft will be provided to cover this phase of the mission.

Extended Earth Orbit Coverage

From Tables 2 and 3, it is apparent that the coverage gap reduction provided by CYI for long duration Apollo Earth-orbited missions is slight. There is no reduction in gaps provided by CYI when both ship and land stations are considered. Computed coverage provided by all Apollo stations of duration greater than 2 minutes is shown in Figures 2-6.

Extension of North American Complex "Continuous Coverage"

Table 4 shows the increase in continuity of coverage that CYI provides for those orbits and launch azimuths for which the North American station complex provides coverage of 15 minutes or more. Of the 27 such cases, CYI improves the continuity of coverage of 8 of these by as much as 50%.

Note that CYI is on the down range end of such coverage, so that its telemetry function would probably be of greater importance rather than its up-data function.

Summary and Recommendations

From the above discussion, it is apparent that:

1. CYI is a necessary tracking, telemetry, up-data, and voice station for (a) confirmation of Earth orbit, (b) SIVB/IU checkout prior to injection or the first orbit, and (c) early-abort support capability.

2. CYI is now equipped with only a single tracking data source (a C-band MPS-26 radar).

3. Although CYI contribution to the coverage of extended Earth orbital missions is small, the increase in "continuous coverage" of the North American station complex is significant for the test missions.

4. CYI will not be able to send up-data to Block II CSM spacecraft without a complete unified S-band station. It could only transmit data by UHF voice to the astronauts in the spacecraft and this is not a satisfactory substitute.

5. CYI is able to send data to the SIVB/IU using its UHF command transmitter for the Saturn IB missions. As presently planned, this UHF receiver in the SIVB/IU will be deleted for Saturn V missions so that CYI would be unable to send data to the SIVB/IU without Unified S-band equipment.

6. CYI coverage during the post-injection phase is redundant.

The above results support our recommendation that the Canary Island site be equipped with a complete Unified S-band station in time for the Block II CSM flights on Saturn IB and Saturn V.

2021-$\frac{JJH}{JPM}$-rc

J. J. Hibbert

J. P. Maloy

Attached:
Figure 1-6
Table 1-4

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COMMUNICATION AND TRACKING COVERAGE

DURING FIRST HALF OF FIRST ORBIT

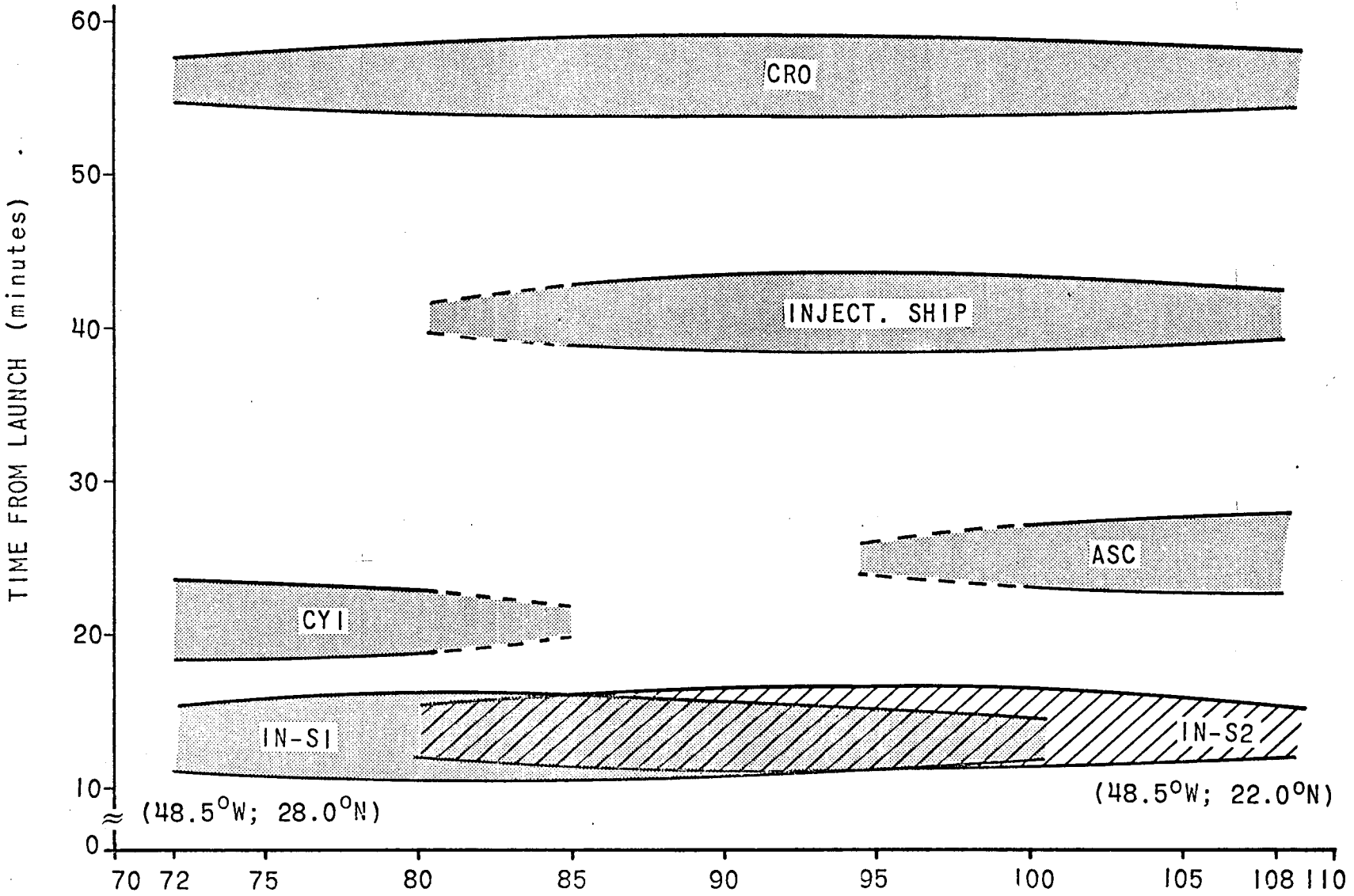


FIGURE 1

COMMUNICATIONS AND TRACKING COVERAGE
DURING FIRST HALF OF FIRST ORBIT

Launch Azimuth	Insertion Ship #1 In-S1 (48.5°W,28.8N)	Insertion Ship #2 In-S2 (48.5°W,22.8N)	Canary Island CYI	Ascension ASC	Injection Ship S#1 (47.8E,25.8)	Carnarvon CRO
72°	*5.0-9.4 (4.4)	-- --	12.1-17.3 (5.2)	-- --	-- --	48.4-51.4 (3.0)
75°	**	**	12.1-17.2 (5.1)	-- --	-- --	48.1-51.8 (3.7)
80°	4.8-9.9 (5.1)	5.8-9.3 (3.5)	12.6-16.7 (4.1)	-- --	-- --	47.8-52.3 (4.5)
85°	**	**	-- --	-- --	32.8-36.7 (3.9)	47.7-52.6 (4.9)
90°	4.9-9.7 (4.8)	5.2-10.2 (3.5)	-- --	-- --	32.3-37.2 (4.9)	47.6-52.8 (5.2)
95°	**	**	-- --	-- --	32.1-37.3 (5.2)	47.6-52.7 (5.1)
100°	5.6-8.3 (2.7)	5.2-10.1 (4.9)	-- --	17.0-21.0 (4.0)	32.2-37.1 (4.9)	47.7-52.6 (4.9)
105°	**	**	-- --	16.5-21.6 (5.1)	32.7-36.8 (4.1)	47.8-52.2 (4.4)
108°	-- --	5.7-9.2 (3.5)	-- --	16.5-21.5 (5.0)	33.2-36.3 (3.1)	48.0-51.9 (3.9)

* Start and end of contact times referenced to time of launch.
** Coverage not computed.
() Coverage duration in minutes.

ASSUMPTIONS: 1. Insertion point at same range from launch site for all launch azimuths.
2. Velocity from launch to insertion same as orbital velocity. Difference in time incurred approximately 5.4 minutes.

TABLE 1

GAPS IN COVERAGE LARGER THAN 1/2 REVOLUTION (47 Min)
FOR CONTACTS OF 2 MIN OR GREATER
(FOR 17 REV.; 5° ELEV; 105 NM ALTITUDE)

LAUNCH AZIMUTH		INCLUDING FOUR SHIPS AND CYI					INCLUDING FOUR SHIPS BUT NOT CYI				
		FROM STA	REV	TO STA	REV	GAP (Min)	FROM STA	REV	TO STA	REV	GAP (Min)
72°	1)	HAW	6	S#1	7	49	SAME				
80°	1)	HAW	6	HAW	7	89	SAME				
	2)	HAW	7	S#4	8	59					
90°	1)	HAW	4	S#1	5	49	SAME				
	2)	HAW	5	HAW	6	89					
	3)	HAW	6	S#4	7	63					
	4)	S#4	12	ETR	13	60					
100°	1)	HAW	3	S#1	4	49	SAME				
	2)	HAW	4	HAW	5	89					
	3)	HAW	5	S#4	6	60					
108°	1)	HAW	3	S#1	4	49	SAME				
	2)	HAW	4	HAW	5	89					

TABLE 2

GAPS IN COVERAGE LARGER THAN 1/2 REVOLUTION (47 Min)

FOR CONTACTS OF 2 MIN or GREATER

(FOR 17 REV.; 5° ELEV; 105 NM ALTITUDE)

LAUNCH AZIMUTH		LAND STATIONS INCLUDING CYI					LAND STATIONS WITHOUT CYI				
		FROM STA	REV	TO STA	REV	GAP (Min)	FROM STA	REV	TO STA	REV	GAP (Min)
72°	1)	GYM	5	HAW	6	80	1)		SAME		
	2)	HAW	6	HAW	7	90	2)		SAME		
	3)	HAW	7	ASC	10	222	3)		SAME		
	4)	GUM	10	CYI	12	145	4)	GUM	10	MAD	13	241
	5)	CYI	12	CYI	13	89					
80°	1)	GYM	4	GUM	5	65	1)		SAME		
	2)	HAW	5	HAW	6	79	2)		SAME		
	3)	HAW	6	HAW	7	89	3)		SAME		
	4)	HAW	7	ASC	9	130	4)		SAME		
	5)	GUM	9	ASC	10	48	5)		SAME		
	6)	GUM	10	CYI	12	145	6)	GUM	10	ETR	13	227
	7)	CYI	12	ETR	13	78					

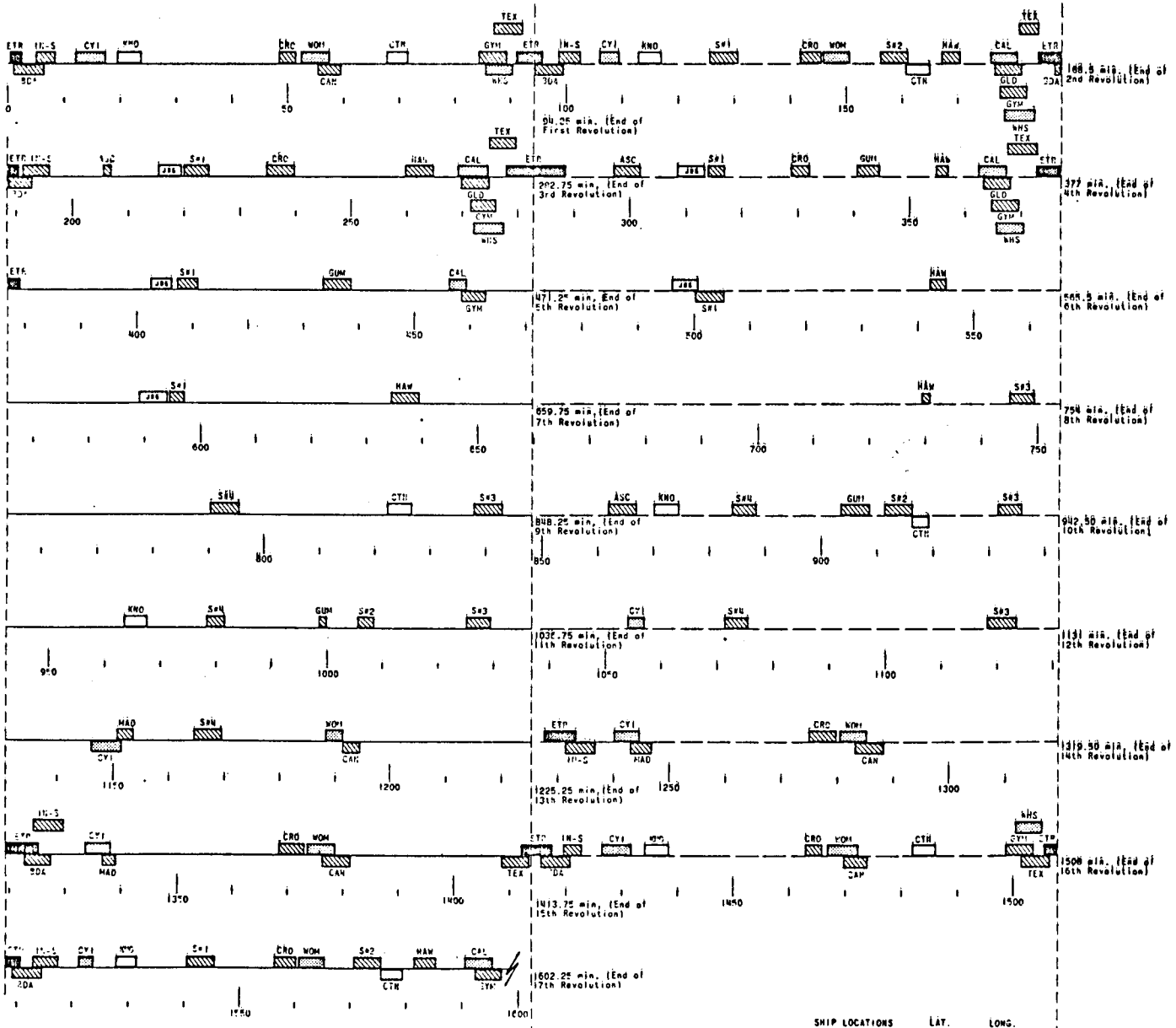
TABLE 3

LAUNCH AZIMUTH		LAND STATIONS INCLUDING CYI					LAND STATIONS WITHOUT CYI				
		From STA	From REV	To STA	To REV	Gap (MIN)	From STA	From REV	To STA	To REV	Gap (MIN)
90°	1)	GYM	3	GUM	4	64	1) SAME				
	2)	HAW	4	HAW	5	90	2) SAME				
	3)	HAW	5	HAW	6	89	3) SAME				
	4)	HAW	6	ASC	8	130	4) SAME				
	5)	GUM	8	ASC	9	48	5) SAME				
	6)	GUM	9	CYI	11	145	6) GUM	9	ETR	12	227
	7)	CYI	11	ETR	12	79	7) ETR	12	ETR	13	86
	8)	CYI	12	ETR	13	74					
100°	1)	TEX	2	GUM	3	62	1) SAME				
	2)	HAW	3	HAW	4	90	2) SAME				
	3)	HAW	4	HAW	5	89	3) SAME				
	4)	HAW	5	ASC	7	131	4) SAME				
	5)	GUM	7	ASC	8	48	5) SAME				
	6)	GUM	8	CYI	10	146	6) GUM	8	ANT	11	228
	7)	CYI	10	ANT	11	79	7) ANT	11	CAN	11	53
108°	1)	ETR	2	GUM	2	53	1) SAME				
	2)	GYM	2	HAW	3	80	2) SAME				
	3)	HAW	3	HAW	4	90	3) SAME				
	4)	HAW	4	HAW	5	89	4) SAME				
	5)	HAW	5	ASC	7	131	5) SAME				
	6)	GUM	8	CYI	10	146	6) GUM	8	MAD	10	151

TABLE 3 (CONTD.)

TRACKING COVERAGE

5° ELEV.; 105 N.M. ALT.; 72° LAUNCH AZIMUTH



SHIP LOCATIONS	LAT.	LONG.
SA1	25.00°S	47.00°E
SA2	5.00°S	170.00°E
SA3	27.00°S	112.00°W
SA4	25.00°N	65.00°E

FIGURE 2

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TRACKING COVERAGE 5°

ELEV.; 105 N.M. ALT.; 80° LAUNCH AZIMUTH

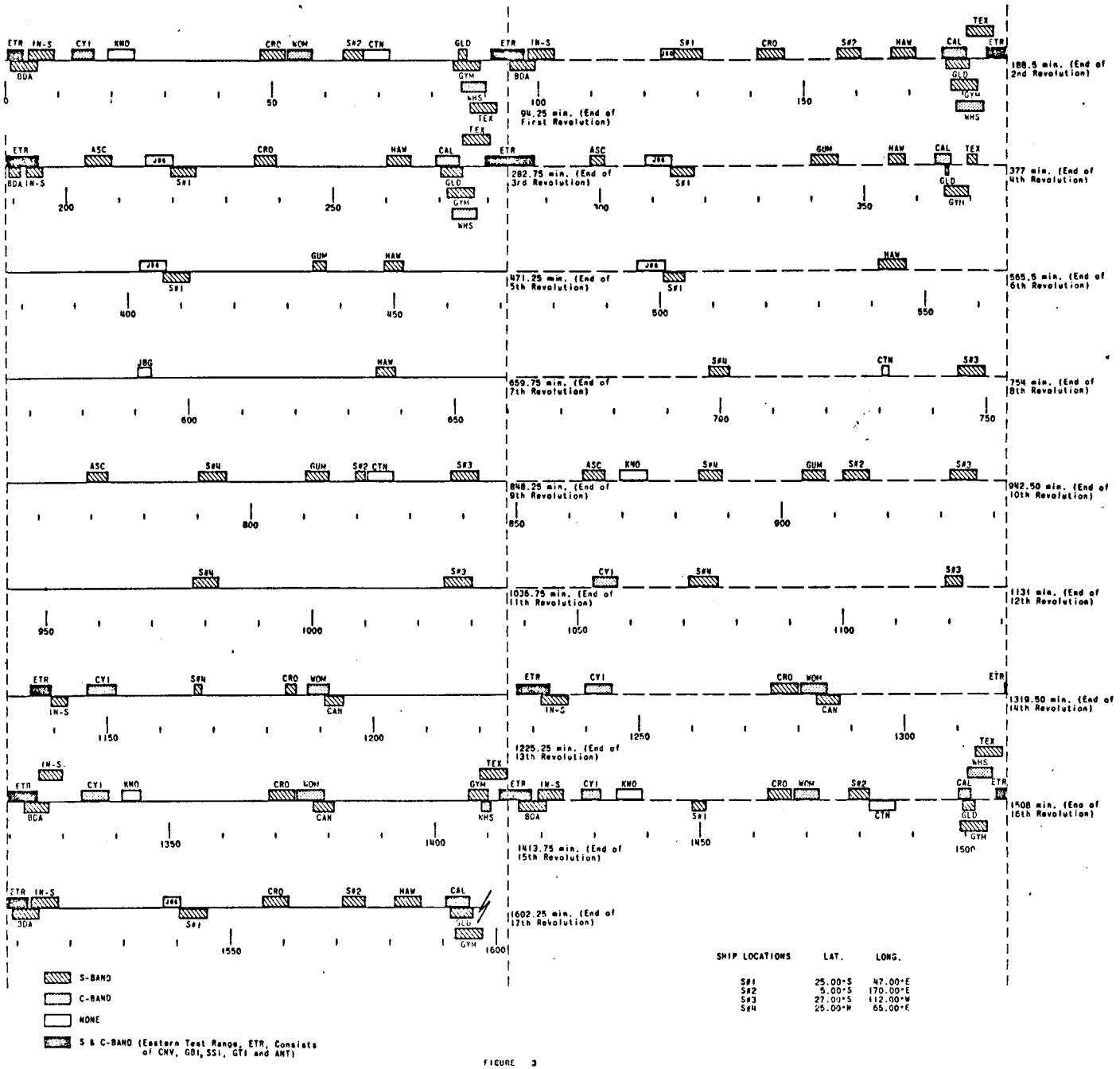
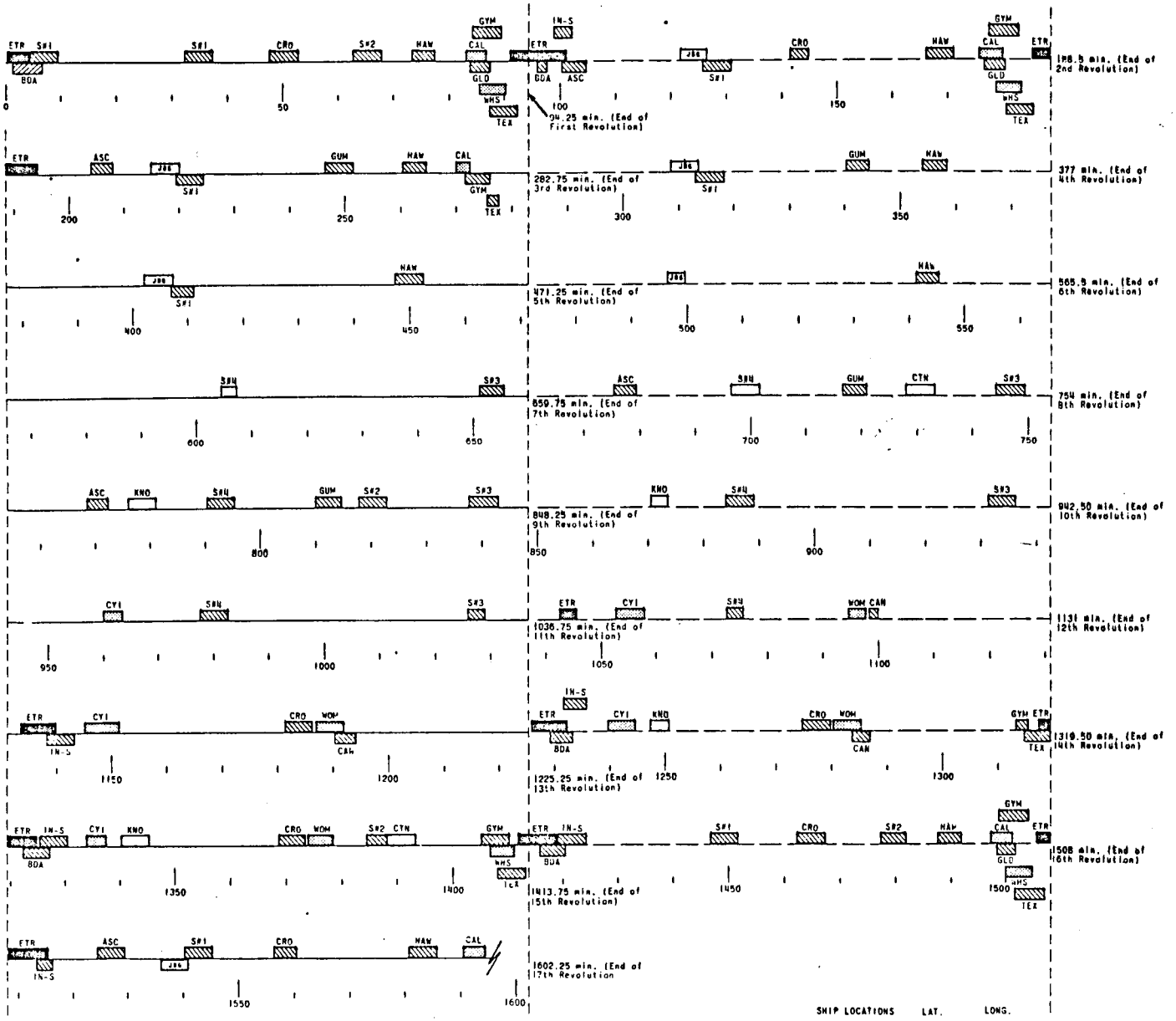


FIGURE 3

TRACKING COVERAGE

5° ELEV.; 105 N.M. ALT.; 90° LAUNCH AZIMUTH



S-BAND

C-BAND

NONE

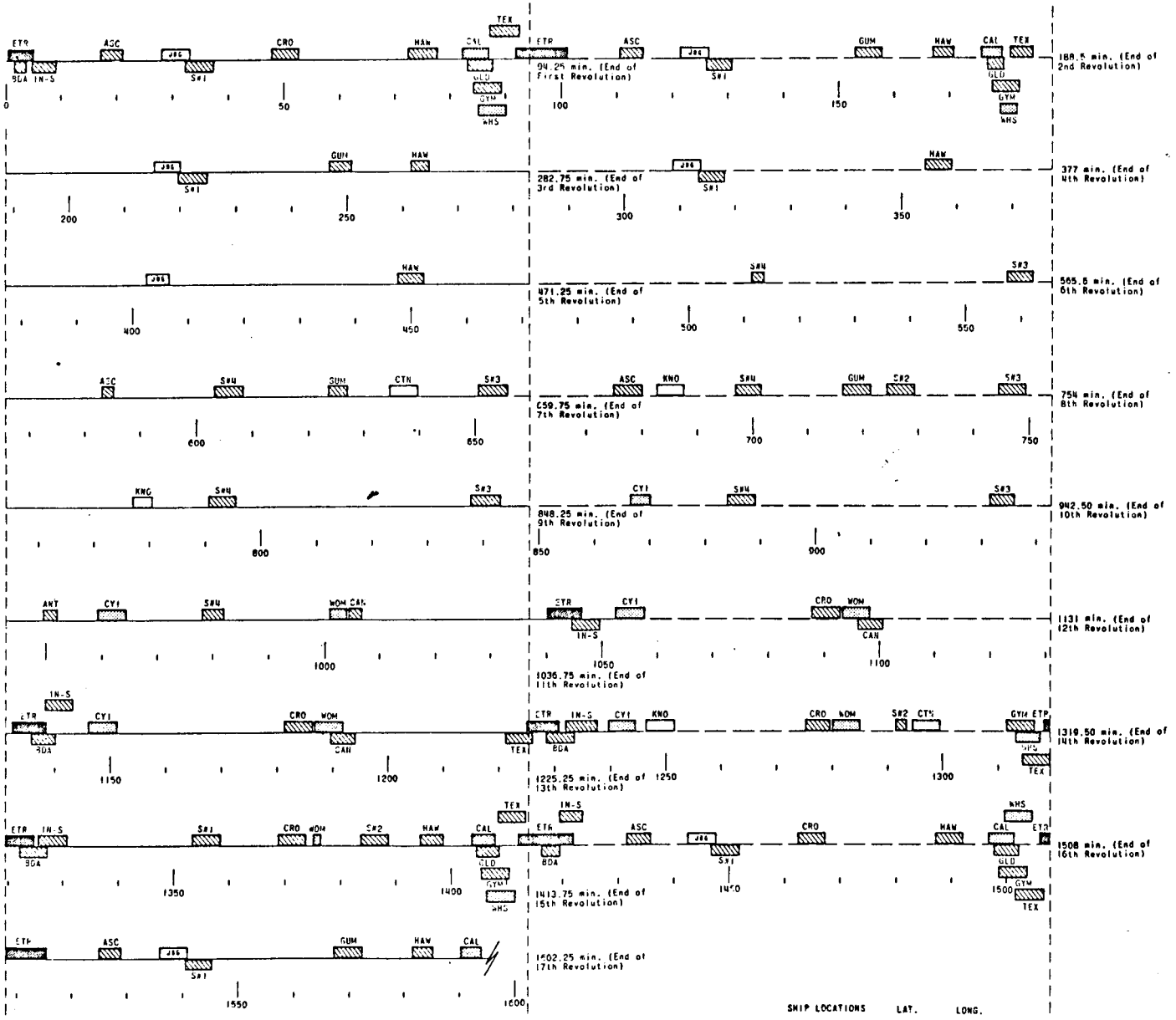
S & C-BAND (Eastern Test Range, ETR, Consists of CNV, GMI, SSI, GTI and AHT)

SHIP LOCATIONS	LAT.	LONG.
S#1	25.00°S	147.00°E
S#2	5.00°S	170.00°E
S#3	27.00°S	112.00°W
S#4	25.00°N	65.00°E

FIGURE 4

TRACKING COVERAGE

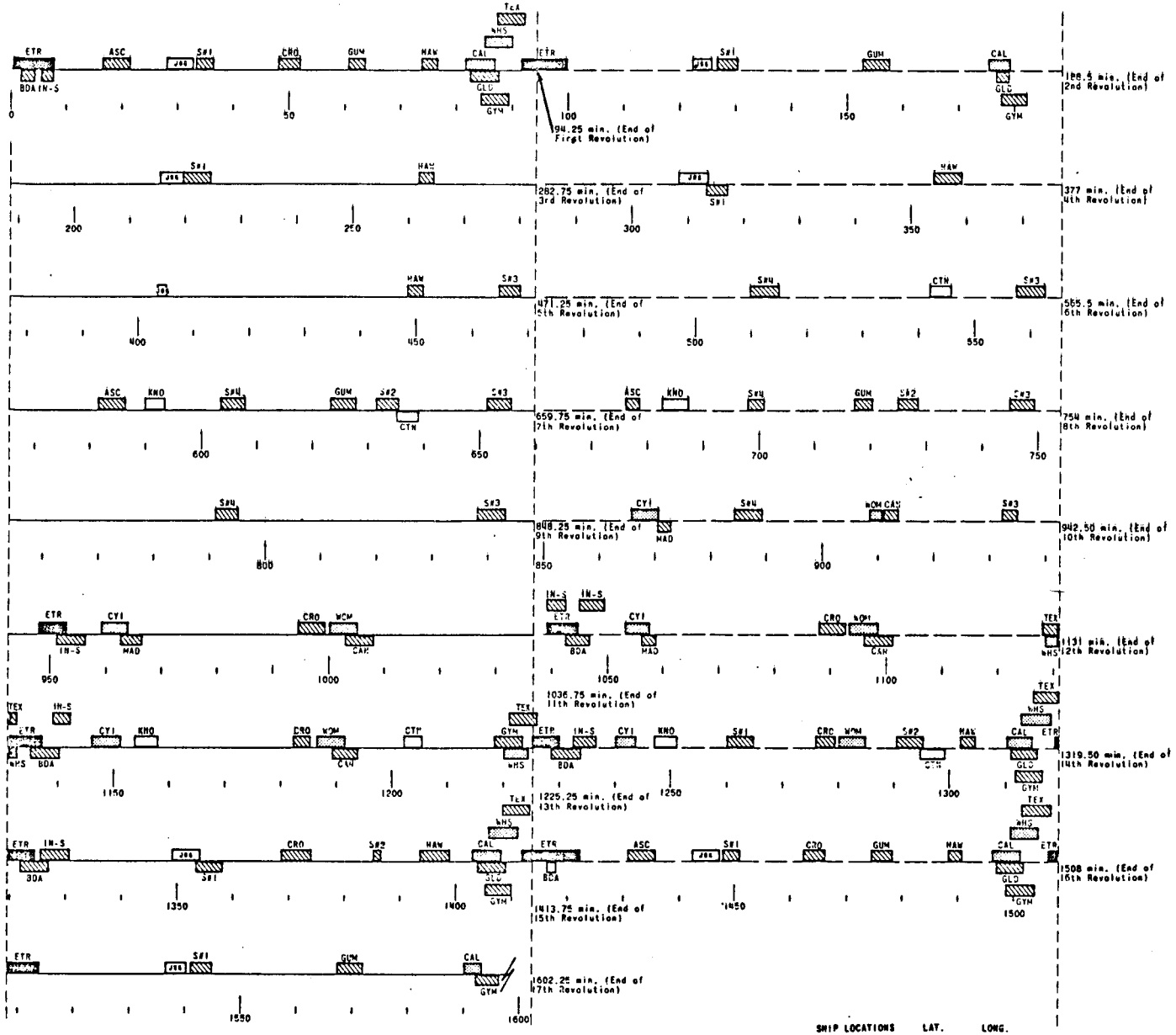
5° ELEV.; 105 N.M. ALT.; 100° LAUNCH AZIMUTH



SHIP LOCATIONS	LAT.	LONG.
S#1	25.00°S	47.00°E
S#2	5.00°S	170.00°E
S#3	27.00°S	112.00°W
S#4	25.00°N	65.00°E

FIGURE 5

TRACKING COVERAGE
5° ELEV.; 105 N.M. ALT.; 108° LAUNCH AZIMUTH



SHIP LOCATIONS	LAT.	LONG.
S#1	25.00°S	47.00°E
S#2	5.00°S	170.00°E
S#3	27.00°S	112.00°W
S#4	25.00°N	65.00°E

FIGURE 6

CASES WHERE CANARY ISLANDS (CYI) ADDS TO "CONTINUOUS" COVERAGE OF NORTH AMERICAN STATION COMPLEX

(17 REVS; 5° ELEV; 105 NM ALTITUDE)

LAUNCH AZIMUTH	REV	FROM STA	TO STA	COVERAGE DURATION (MIN)	GAP (INS. SHIP TO CYI) (MIN)	LENGTH OF CYI CONTACT (MIN)	COVERAGE DURATION WITH CYI (MIN)
72°	1-2	GYM	IN-S1	20	2.9	3.4	26
	15-16	TEX	IN-S1	16	2.6	5.2	24
	16-17	GYM	IN-S1	19	3.1	2.8	25
80°	15-16	GYM	IN-S1	19	2.7	3.7	25
90°	14-15	GYM	IN-S1	17	2.9	3.7	24
100°	13-14	TEX	IN-S2	15	3.2	4.6	23
108°	12-13	TEX	IN-S2	15	3.0	5.1	23
	13-14	GYM	IN-S2	19	3.0	3.6	26

INSERTION SHIP LOCATIONS:

	LONG.	LAT
IN-S1	48.5°W	28.0°N
IN-S2	48.5°W	22.0°N

TABLE 4

STATIONS	CYI	ACN	TAN	CRO	GWM	HAW	CONT. USA	ALL STATIONS	PERCENT COVERAGE FOR CYI
Number of Contacts	11	11	14	13	13	14	17	91	12%
Contact Duration in Minutes	83	71	98	95	82	95	240	632	13%

TABLE I

MSFN STATION COVERAGE FOR 29 REVOLUTION AT AN ALTITUDE OF 210 NAUTICAL MILES

LAUNCH AZIMUTH = 84.8°

Table IA. – Mission Contact Statistics

STATIONS	CYI	ACN	TAN	CRO	GWM	HAW	*CONT USA	ALL STATIONS	SHIPS	SHIPS & STATIONS	% COVERAGE WITH SHIPS	% COVERAGE WITHOUT SHIPS
NUMBER OF CONTACTS	330	300	390	360	345	360	495	2,580	1,035	3,615	-----	-------
TOTAL MINUTES CONTACT	2,977	2,662	3577	3,300	3,112	3,390	8,407	27,427	9,105	36,532	43	32

Total Mission - 56 Days

Total Revolutions - 821

*Continental U.S.A. Includes:

Guaymas, Corpus Christi, Meritt Island, Grand Turk Island, Bermuda, Antigua, Grand Bahama Island

TABLE II

GAPS IN MSFN COVERAGE (ASSUMMING NO SHIP STATIONS)

(IN A TWO DAY PERIOD)

GAP PERIODS EXCEEDING

		35 Min.	75	100	120	200
A)	ALL GROUND STATIONS	33	5	1	1	0
B)	WITHOUT CYI	38	6	2	1	1
C)	WITHOUT TAN	37	6	1	1	0
D)	WITHOUT TAN AND CYI	42	7	2	1	1

REVOLUTION PERIOD = 98.7 Minutes

ALTITUDE = 210 Nautical Miles

BELLCOMM, INC.

Subject: Review of Role of MSFN Station at Grand Canary Island in Apollo and AAP

From: J. P. Maloy

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